THE INTENSE MIDWEST STORM OF MARCH 25–27, 1950

SIDNEY TEWELES, JR., AND LEWIS C. NORTON

WBAN Analysis Center, U. S. Weather Bureau,
Washington, D. C.

INTRODUCTION

Severe weather, ranging from dust storms and sandstorms in New Mexico and west Texas to blizzards in the Dakotas, prevailed in the northern Plains area and on the east slope of the Rockies on March 25–27, 1950. These conditions were accompanied by a Low which deepened very rapidly in eastern Colorado and western Nebraska on the 25th and which further intensified as it continued a general north-northeastward course into the Dakotas and Minnesota. At many locations, passage of the Low resulted in the lowest pressure of record.

It is of interest from a synoptic standpoint to examine not only conditions when the storm was most active, but also to investigate some of the causes and effects leading up to the most intense development. To do this requires a study of synoptic conditions for several days in advance and for an area extending some thousands of miles from the region of severe weather.

PRECEDENT SYNOPTIC CONDITIONS

On March 21 a deepening surface wave about 300 miles south of the Aleutian Islands moved rapidly eastward and at 1330 EST on the 22d (fig. 1) the resulting Low, then occluded, was centered at 48° N., 146° W. At that time it had its lowest central pressure, 980 mb., and thereafter decelerated and slowly filled, the occluded front and warm sector becoming dissociated from the low pressure center. The circulation of this Low resulted in the movement of a large quantity of cold air from northern Siberia into the Gulf of Alaska.

Far to the west between Japan and the Aleutian Islands, a strong current of warm air, both at the surface and aloft, moved northeastward, then eastward and southeastward into close contact with the cold air current which was nearer the center of the Gulf of Alaska Low. This confluence of differing currents produced a strong temperature gradient at intermediate levels along the western and southwestern boundary of the cold air, and a resulting strong northwesterly thermal wind component became established over the northerly surface winds which appear near longitude 155° W. in figure 1 and longitude 135° W. in figure 2. The existence of such a large thermal wind component required very strong northwesterly winds aloft. The confluence of upper level warm and cold air currents, and the resulting strong temperature gradient aloft, have been advanced by Namias and Clapp [1] as "ssential features in their theory of the formation of the ejet stream." Figure 3 shows the resulting strong northwesterly current at 500 mb. off the west coast of North America at 2200 EST, March 24. This figure also shows the great amplitude of the isotherm pattern, with temperatures of −15° C. over the stationary ship at 50° N., 145° W., and −30° C. over northern California. In addition, the thermal wind component indicated by the isotherm field in the vicinity of 40° N., 130° W., required that winds between the 500- and 300-mb. levels in that region be even stronger and more northerly. This strong upper

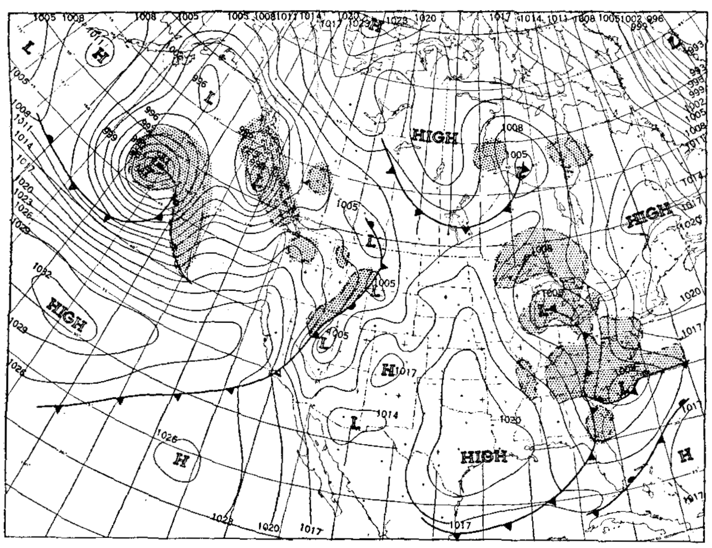

FIGURE 1.—Surface weather map for 1330 EST, March 22, 1950. Shading indicates areas of active precipitation.

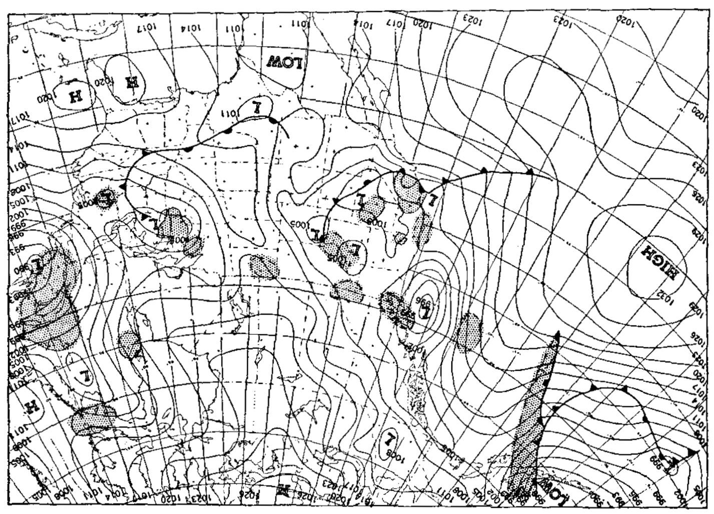

FIGURE 2.—Surface weather map for 1330 EST, March 24, 1950. Shading indicates areas of active precipitation.

level flow was directed into a region of weaker pressure gradient, a condition favorable for conversion of some of the kinetic energy into potential energy in a manner discussed by Wobus and Norton [2].

On the 23d, high speed parcels first began to enter the weak pressure gradient of a trough aloft just off the southern California coast (not illustrated). These air parcels decelerated by "overshooting" into higher pressure with consequent sharpening and retardation of the trough, a process which tended to strengthen the gradient in the portion of the trough near the 30th parallel. After the gradient in the southern portion of the trough had increased, high speed parcels entering that portion of the trough were able to pass through to the east with undiminished speed. Figure 3, for the 500-mb. level, 2200 EST, March 24, shows the trough at this stage of development.

Intensification of the trough in its southern portion was accompanied by a large drop in the height of the 500-mb. surface along the California coast, and the reflection of this pressure drop is found at sea level in the sudden development of a frontal wave, which at 1330 EST, March 24 (fig. 2), was just southwest of San Francisco. Within 12 hours this wave deepened 15 mb. and moved rapidly into Utah, where it was centered at 0130 EST of the 25th (fig. 4).

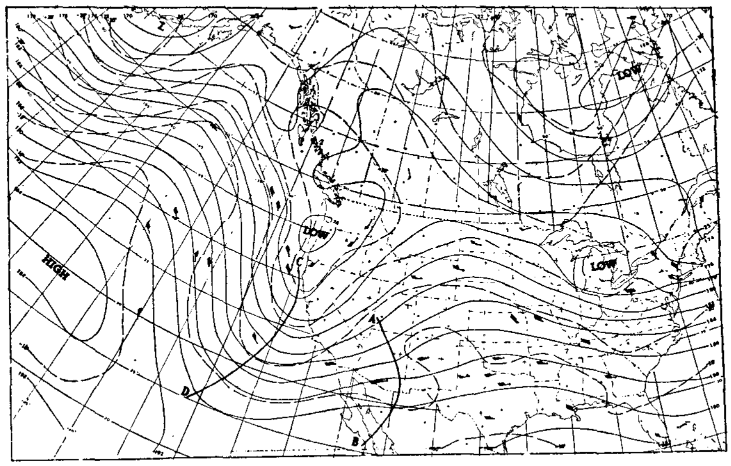

Figure 3.—500-mb. chart for 2200 EST, March 24, 1950. Contours (solid lines) at 200-ft. intervals are labeled in hundreds of geopotential feet. Isotherms (dashed lines) are drawn for intervals of 5° C. Winds are plotted in Beaufort scale.

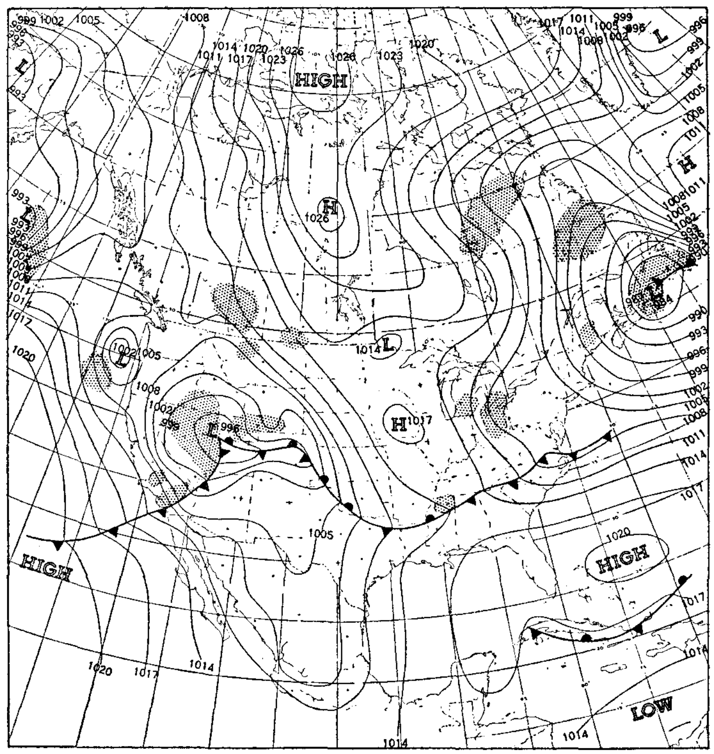

Figure 4.—Surface weather map for 0130 EST, March 25, 1950. Shading indicates areas of active precipitation.

TEMPERATURE CHANGES ALOFT

Figure 5 shows the soundings at Ely, Nev., for 1000 EST and 2200 EST of the 24th. At both times Ely was very close to the front. However, the wave had approached to within 50 miles of Ely by 2200 EST of the 24th so that these soundings reveal the levels in the atmosphere responsible for the 12-hour pressure fall over Nevada. Comparison of the two soundings shows a slight net cooling from the ground up to 260 mb. The layer between 260 and 100 mb. was appreciably warmer and lighter at the end of the 12-hour period. This marked high level warming was sufficient to compensate for an increase of pressures at heights above the 100-mb. level and the slight net cooling below 260 mb., and in addition, to account for a drop of 6 mb. in station pressure (7.5 mb. in pressure as reduced to sea level). Most of the warming in the high levels above Ely can be explained by advection from the west and northwest. But, as the trough aloft moved over Nevada by the evening of the 25th, the 200-mb. chart showed warm air of greater extent and of higher temperature than any which could have moved into that region by purely horizontal advection from the west and northwest. Therefore, it is probable that adiabatic warming also occurred as air in the upper levels was drawn downward by horizontal divergence at intermediate levels. This horizontal divergence in turn can be accounted for if the strong winds at 500 mb., as illustrated in figure 3 where wind speeds are near 100 knots at San Diego and Tucson, had a cross-isobar component toward higher pressure. Such cross-isobar flow, accompanying an adjustment of pressure gradient as strong winds were injected into the region south of Nevada, appears to have been a factor in drawing air out of the intermediate levels over Nevada.

The lowest sea level pressure attained by the Low before it redeveloped east of the Continental Divide was near 990 mb. in the vicinity of Salt Lake City, Utah. The lowest pressure reported in the Low after redevelopment east of the Divide was 968 mb. at 0130 EST, March

27 at Tyndall, S. Dak. Figure 5 includes a sounding from Omaha at 1000 EST of March 26 when that station reported a sea level pressure of 982 mb. and was in the warm sector about 200 miles east-northeast of the Low center. Comparing this sounding with that from Ely at 2200 EST, March 24 when that station was very near the center, we find higher temperatures at Omaha at all levels up to 250 mb. and little difference above 250 mb. This very warm air in the lower three-quarters of the atmosphere was a factor in the attainment of lower central pressures east of the Rockies as compared to the Great Basin.

This observed increase of tropospheric temperatures within the life history of a deepening cyclone is in contrast to results reported by Vederman [3] in his study of temperature changes aloft over 25 Lows in the United States *east of the Rockies*, all of which deepened 10 millibars or more. Vederman found in almost all cases, as a Low deepened, the air column over the moving center became progressively cooler at all levels below 400 mb., and the removal of mass necessary to produce the lowering of surface pressure took place at levels above 400 mb. as shown by marked warming he observed between 300 and 100 mb. However, in the case under discussion, while the Low appears on the synoptic chart as a system having a continuous movement across the Plateau and into the Plains area, its rapid deepening along the east slope of the Rockies was in effect a new development, involving a new and warmer air mass which was not present over the Plateau. Warming of the troposphere over the Low center was therefore associated with transformation of the system from a Plateau Low to a Plains Low. Further deepening as the Low moved through the northern Plains was accompanied by cooling of the troposphere over the moving center, in agreement with Vederman's results.

The high temperatures attained below 700 mb. may be seen by comparing the thickness charts in figures 6 and 7. These charts show the difference in height between the 1000-mb. and 700-mb. levels, and since a given thickness corresponds to a fixed value of mean virtual temperature between the levels, the lines are labeled in degrees Centigrade at one end and thickness, in geopotential feet, on the other end. The large arrows with hollow heads show the flow of air at 850 mb. from warm to cold areas and indicate, in a qualitative manner, the areas where warm advection is taking place. In an analogous fashion, the

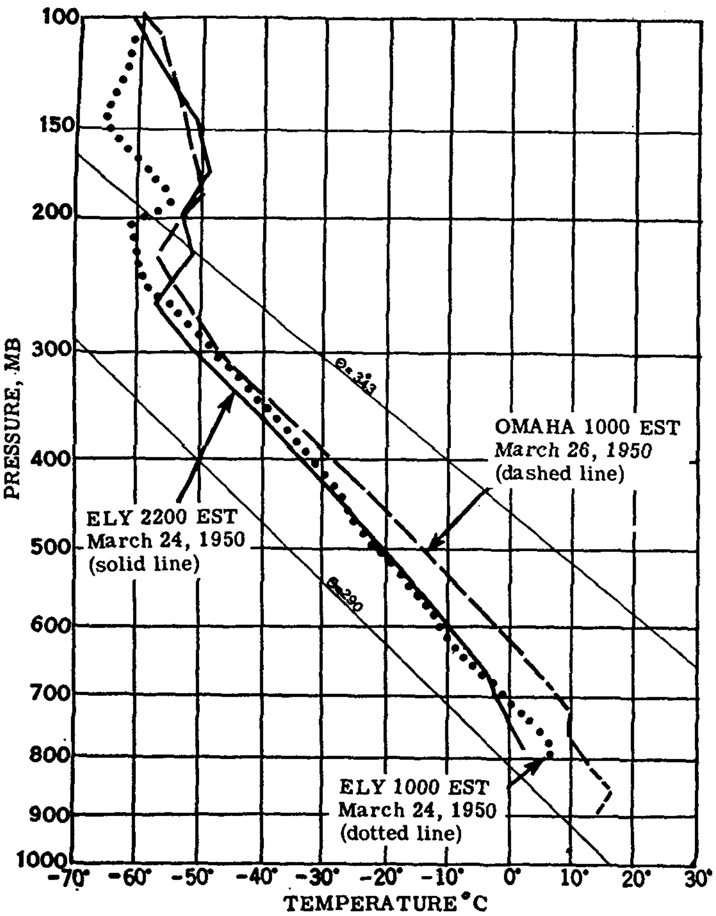

FIGURE 5.—Radiosonde observations from Ely, Nev., and Omaha, Nebr.

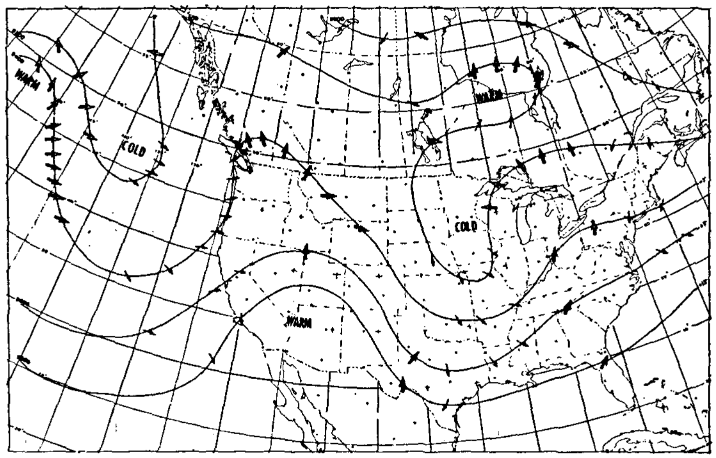

FIGURE 6.—Height-difference chart, 1000-700-mb., for 2200 EST, March 21, 1950. Height-difference (mean virtual temperature) lines at 200-ft. intervals are labeled in geopotential feet on the left and in degrees Centigrade on the right.

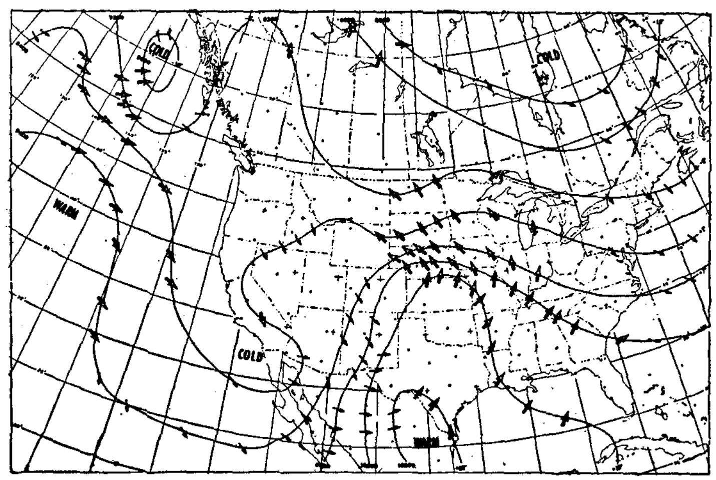

FIGURE 7.—Height-difference chart, 1000-700-mb., for 2200 EST, March 25, 1950. (See fig. 6 for explanation.)

small solid arrows show cold advection. Rough estimates of temperature advection can be made from these charts, though vertical motion, radiation, and other factors limit the accuracy of the results. Figure 6, the thickness chart for 2200 EST on the 21st, shows cold air over the central United States. During the succeeding four days, except for a short break with passage of a front on the 23d, there was continued warm advection over the Plains region, raising temperatures to the much higher values indicated in the thickness chart for 2200 EST, March 25 (fig. 7).

But as the Plains Low developed and deepened on the 25th and 26th, the very low surface pressure at the center resulted not only from high temperature in the lower troposphere, but also from the appearance over the center of warmer air aloft between the 300-mb. and 100-mb. levels, as may be seen by comparing the soundings taken over Omaha at 12-hour intervals (fig. 8). At the time of the sounding for 1000 EST of the 26th (fig. 8, solid line), Omaha was about 200 miles ahead of the surface cold front. This combined effect of the appearance of warmer air both at lower levels and aloft over deepening Lows has been described by Wulf and Obloy [4].

CHANGES IN THE UPPER TROPOSPHERE

A comparison between figure 9, the 500-mb. chart for 2200 EST, March 26, and figure 3, the corresponding chart 48 hours earlier, will illustrate some of the significant changes in the upper troposphere during development of the storm. The leading edge, CD, of the northwesterly winds moved forward about 1,200 miles and was still identified with the axis of cold air. In the same period, the leading edge, AB, of the very strong westerlies moved eastward about 1,100 miles. Figure 9 shows gradient wind speeds in excess of 100 knots in the region of strong gradient and slight anticyclonic curvature over eastern Texas. Since the average speed of the line AB was between 20 and 25 knots, the much higher speed of individual air parcels required that they move across the line and far to the east during the 48-hour period. These air parcels necessarily decelerated after crossing the line AB, because they encountered weaker gradient and were therefore deflected toward higher pressure, a factor contributing toward lowering of pressures, surface and aloft, *in the vicinity* of A. Thus some kinetic energy of the winds aloft was converted into potential energy within the storm area. This built-up potential energy, consisting of strong horizontal pressure gradient force, contributed in turn to the strong winds observed both at the surface and aloft, within the storm.

It is an interesting sidelight to note some further effects of the air parcels after they moved through the line AB of figure 9. Their trajectory took them at reduced but still high speeds (between 50 and 70 knots) across the ridge over the northeastern United States. At the time of

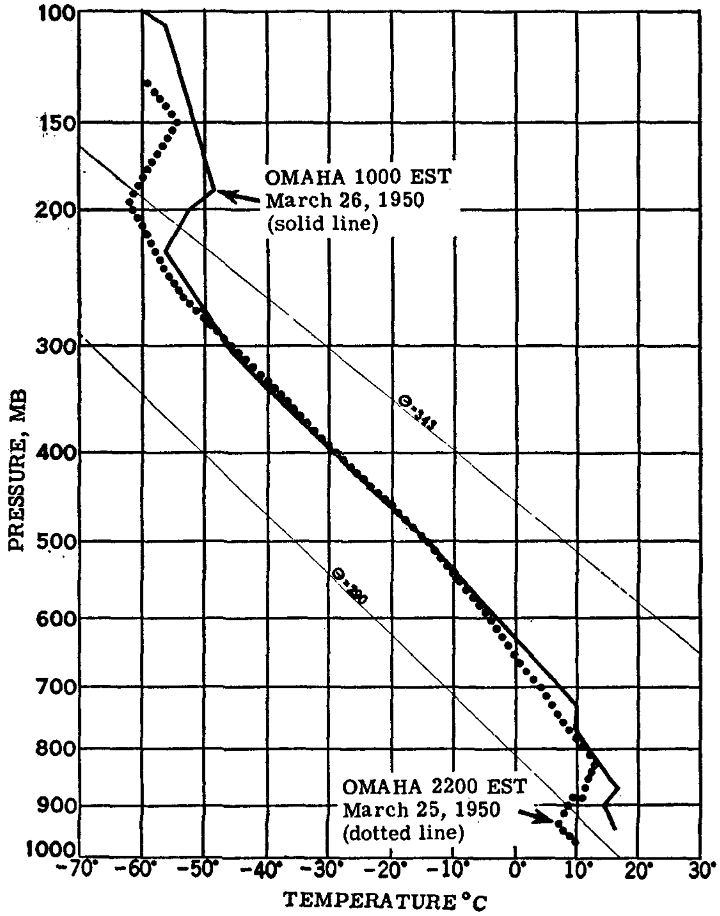

FIGURE 8.—Radiosonde observations from Omaha, Nebr.

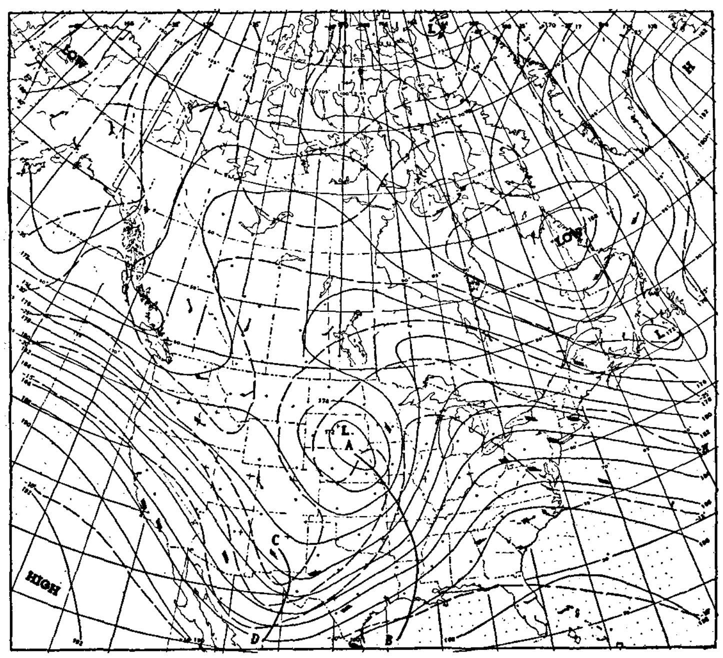

FIGURE 9.—500-mb. chart for 2200 EST, March 26, 1950. Contours (solid lines) at 200-ft. intervals are labeled in hundreds of geopotential feet. Isotherms (dashed lines) are drawn for intervals of 5° C. Winds are plotted in Beaufort scale.

the map in figure 9, this current was a factor in the production of a new "jet" of northwest winds off the east coast as the warm air came into juxtaposition with cold air flowing across Maine and the Maritime Provinces, a situation suggesting propagation of energy downstream from one system to another.

MOVEMENT AND EFFECTS OF THE STORM

As the frontal system of the Low became more deeply occluded, the central pressure dropped to 968 mb. (reported at Tyndall, S. Dak., 0130 EST of the 27th). Many stations near the path of the Low center (see Chart III) reported the lowest sea level pressures of their entire record (see table 1).

Upon entering Nebraska, the Low curved toward the north and decelerated. In figure 10, at 0130 EST of the 27th, the Low was almost stationary near Sioux Falls and was about to accelerate along a path to the east of and at a right angle to its previous path. The change in direction was associated with low level cooling in the northwest sector of the Low. Cold air as it lay over Canada is shown to the north of the $-5°$ C. isotherm in figure 7. One day later, as shown in figure 10, the circulation of the Low had moved far enough northeastward to tap this supply of cold air. As temperatures dropped on March 27 and 28 in the snow-covered Dakotas, northerly winds increased, causing blizzard conditions. In North Dakota, heavy drifting snow blocked highways and forced many schools to close.

TABLE 1.—*List of new record low sea level pressures resulting from the storm of March 25–27, 1950*

W. B. station	New record low sea level pressure	
	mb.	*in.*
Concordia, Kans	972.9	28.73
Grand Island, Nebr	969.9	28.64
Huron, S. Dak	970.5	28.66
Norfolk, Nebr	970.9	28.67
North Platte, Nebr	972.2	28.71
Omaha, Nebr	973.9	28.76
Pueblo, Colo	976.6	28.84
Sioux City, Iowa	970.5	28.66
Sioux Falls, S. Dak	969.5	28.63

During the 48 hours between 0130 EST, March 25 (fig. 4), and 0130 EST, March 27 (fig. 10), the warm front, which extended east and southeast of the Low, moved northward, and rain and snow began falling over the northern States from Montana to Pennsylvania. Warm temperatures and rain greatly reduced the depth and extent of the snow cover from Wisconsin eastward.

There were dust storms on the afternoon of March 25 in New Mexico east of the divide, Kansas, Oklahoma, and western and central Texas. Strong dry winds descending from the Plateau prevented any substantial influx of maritime tropical air, with the result that no rain fell in that area during the progress of the storm. This section had received almost no rain for 6 weeks, and the amount

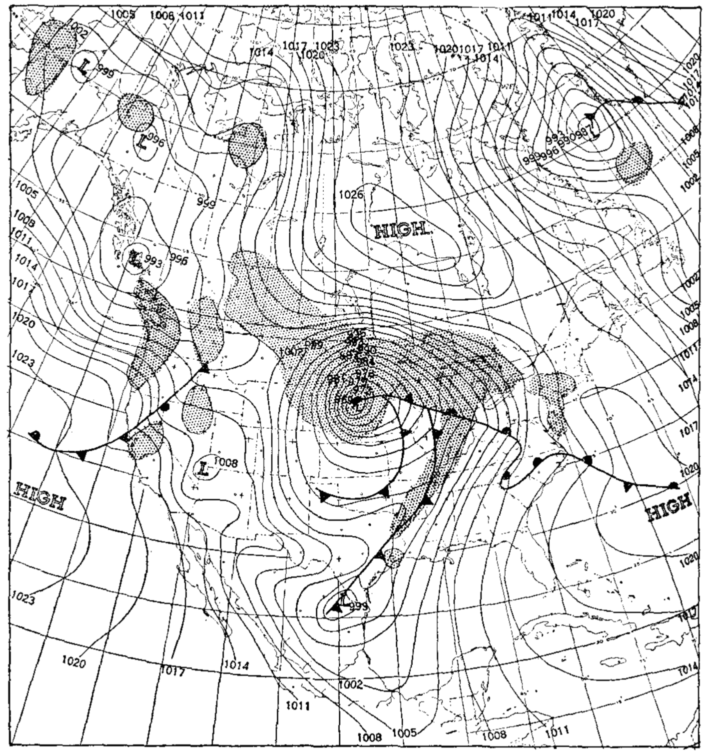

FIGURE 10.—Surface weather map for 0130 EST, March 27, 1950. Shading indicates areas of active precipitation.

during the entire winter was far below normal. Wind speeds generally were more than 40 miles per hour and some stations reported winds up to 70 miles per hour for short periods. Temperature-dew point differences were as much as 60° to 80° F.; at Lamar, Colo., a temperature of 79° F. was reported with a dew point of $-8°$ F. Great quantities of rich top soil were blown away. Soil damage and drought caused some farmers, particularly in western Oklahoma, to abandon fields planted to small grains.

The main cold front of the storm passed Albuquerque during the afternoon of the 25th. The dust storm was intensified by rapidly moving turbulent air just behind the front, causing dust to be lifted to higher levels and to be carried far to the east, including the southeastern part of the country where the cold front was also accompanied by considerable severe weather.

On the afternoon of the 26th, when the cold front approached the deep flow of maritime tropical air over Missouri, Arkansas, and extreme eastern Texas, thunderstorm and shower activity broke out in the warm moist air. At the time of the map shown in figure 10, 0130 EST of the 27th, the heaviest rainfall was occurring near the main cold front from LaCrosse through St. Louis and Little Rock to Houston. As the front moved eastward, rain amounts of more than 2 inches were reported in a band from Little Rock to Indianapolis, and lesser amounts to the east and south. Much of this precipitation fell from thunderstorms along the cold front, but many prefrontal thunderstorms broke out in Illinois and Indiana on the night of the 26th.

Several tornadoes were reported ahead of the cold front as it passed through Arkansas, Louisiana, and Mississippi. In Mississippi, property damage amounted to several hundred thousand dollars. Gusts up to 100 miles per hour were reported at the Jackson, Miss., Airport. Some further wind damage was reported as the front and accompanying thunderstorms moved across Alabama.

By 0130 EST of March 28th, a new Low center formed along the occluded front just north of Lake Huron. During the next 12 hours, the original Low center filled as it crossed northern Wisconsin. At the same time the main cold front passed off the east coast into the Atlantic, and a few snow flurries in the North Central States were all that remained of the weather produced by the storm.

REFERENCES

1. J. Namias and P. F. Clapp, "Confluence Theory of the High Tropospheric Jet Stream," *Journal of Meteorology*, vol. 6, No. 5, October 1949, p. 330–336.
2. H. B. Wobus and L. C. Norton, "Some Synoptic Aspects of a Change in Weather Regime During February, 1950," *Monthly Weather Review*, vol. 78, No. 2, February 1950, p. 31–40.
3. J. Vederman, "Changes in Vertical Mass Distribution over Rapidly Deepening LOWS," *Bulletin of the American Meteorological Society*, vol. 30, No. 9, November 1949, p. 303–309.
4. O. R. Wulf and S. J. Obloy, "The Utilization of the Entire Course of Radiosonde Flights in Weather Diagnosis," *Miscellaneous Reports*, No. 10, University of Chicago Press, 1944, p. 7.

885753—50——2

U. S. GOVERNMENT PRINTING OFFICE: 1950

Blank page retained for pagination